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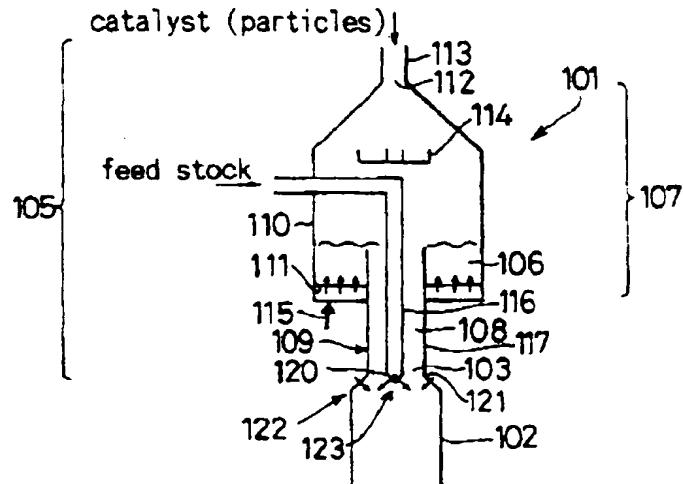
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(54) Apparatus for mixing feed stock and catalyst particles

(57) An apparatus is disclosed for mixing a fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the heavy oil in a reactor which comprises the reactor having in the upper portion a circular port through which the particles are fed, a moving bed forming section disposed on and in communication with the reactor for forming the particles into a cylindrical high-velocity moving bed by falling the particles down-

wardly into the reactor while dispersing circularly the particles, an external fluid feed section located so as to spray the feed stock over the entire upper outer periphery of the cylindrical moving bed passing through the reactor and an internal fluid-feed section located so as to spray the fluid over the entire upper inner periphery corresponding to the outer periphery of the cylindrical moving bed.

FIG.1



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Description

This invention relates to an apparatus for mixing a fluid such as a heavy oil and particles such as a catalyst heated at elevated temperatures.

There are known a reaction system in which solid particles such as a catalyst or a heat medium is brought into contact with a reactant. A moving bed type reactor is a typical example of such reaction system which reactor is classified into one utilizing a concentrated fluidized bed (bubbles-fluidized bed) and the other utilizing a high-speed moving bed (fluidized bed). The high-velocity moving bed is used for a reactor in which a solid and a gas must come into contact for a short period of time. Currently, there has been mainly employed an upflow-type high velocity moving bed reactor so-called "riser-type" in a fluid catalytic cracking apparatus used for the production of a gasoline from a feed stock such as a heavy oil. This reactor is capable of reducing contact time with an improvement of a catalyst in ability leading to an enhancement of selectivity of a final product and suppression in unfavorable excessive cracking reaction.

Recently, a strong demand has been made for an enhancement in selective productivity of a gasoline or a light olefin and an investigation has been conducted for use of a downflow type high velocity moving bed reactor which is free from backmixing affecting adversely an improvement of the selectivity.

Upon production of a gasoline from a feed stock such as a heavy oil using a fluid catalytic cracking apparatus equipped with the existing upflow-type reactor having a high speed moving bed, the contact reaction therein takes several seconds. Whereas upon production of a light olefin the reaction time is required to be reduced in the order of ranging from 0.1 to 1.5 seconds. A rapid mixture of a feed stock and a catalyst and vaporization thereof at the inlet port of a reactor is indispensable in order to conduct the contact reaction in a short period of time. Furthermore, it has become necessary to increase a recycle ratio of a catalyst to an oil to compensate for a reduction in conversion involved with a shortened reaction time. From view of this background, there has been demanded an apparatus which is capable of rapid mixture and vaporization of the feed stock and the catalyst at the inlet of the existing upflow type reactor forming a high speed moving bed and enables a recycle ratio of a catalyst to an oil as several times as greater than that (catalyst / oil ratio of 5 - 8) of a catalytic cracking apparatus for producing a gasoline from a feed stock such as a heavy oil.

With the foregoing difficulties of the prior art in view, the present invention seeks to provide an apparatus which is capable of mixing a fluid and a solid particle uniformly and rapidly.

According to the invention, there is provided an apparatus for mixing a fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the fluid in a reactor which comprises the reactor having in the upper portion a circular port through which the particles are fed, a moving bed forming section disposed on and in communication with the reactor for forming the particles into a cylindrical high-velocity moving bed by falling the particles downwardly into the reactor while dispersing circularly the particles, an external fluid feed section located so as to spray the feed stock over the entire upper outer periphery of the cylindrical moving bed passing through the reactor and an internal fluid-feed section located so as to spray the fluid over the entire upper inner periphery corresponding to the outer periphery of the cylindrical moving bed.

According to another aspect of the invention, there is provided an apparatus for mixing a fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the fluid which comprises a plurality of stand pipes extending vertically, a distributing device for distributing uniformly the particles into the stand pipes, a mixing section positioned below the distributing device from the interior of which the stand pipes extend to the upper interior of the mixing section to feed the particles thereto, a plurality of plates arranged in the mixing section and below the stand pipes for dispersing the particles falling therefrom outwardly in a radial direction and a fluid-feed chamber arranged in the mixing section in surround relation to the outer periphery of each of the stand pipes to spray the fluid downwardly in a vertical direction in close proximity of and in surround relation to the entire outer periphery of the cylindrical particles falling from each of the stand pipes so as to collide with the particles after being dispersed by the plates.

According to further another aspect of the invention, there is provided an apparatus for mixing the fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the fluid which comprises a plurality of stand pipes extending vertically, a distributing device for distributing uniformly the particles into the stand pipes, a mixing section positioned below the distributing device from the interior of which the stand pipes extend into the upper interior of the mixing section to feed the particles thereto, a plurality of plates arranged in the mixing section and below the stand pipes for dispersing the particles falling therefrom outwardly in a radial direction and a fluid-feed chamber arranged in the mixing section in surround relation to the outer periphery of each of the stand pipes to spray the fluid over the entire outer periphery of the cylindrical particles falling from each of the stand pipes.

It is necessary for a short contact reaction to conduct a rapid uniform mixture of and vaporization of a feed stock and particles (catalyst) at the inlet of a reactor. Therefore, it is required to supply a feed stock in the form of fine droplet, for example by means of spray and to disperse uniformly a catalyst in the form of solid particles. The uniform mixture can be effected in a wide space but fails to be fully accomplished in a limited space. An extensive research and development to seek an alternative for solving the problem results in the following conclusion.

In this alternative solution, after a feed stock in droplet form is fined to some extent by means of a spray nozzle,

the sprayed feed stock is brought into collision with solid particles so as to be further fined by impact caused by the collision. Importantly solid particles are increased in surface area as large as possible so that the surface thereof can entirely collide with the sprayed feed stock. Hereinafter, it is described as to what kind of shape the particles take to have a large surface area in a limited size of space.

Referring to Figs. 9, 11 and 13, there are shown tubular reactors in a state that particles 153 flow downwardly with the volume thereof being controlled. Figs 10, 12 and 12 each shows a cross-sectional view of each tubular reactor 150, 151 and 152 shown in Figs 9, 11 and 13. As shown in these figures, the flowing particles in the cross section of each of the tubular reactors take simple forms among which those shown in Fig 10 (c), 12 and 14 are suitable for uniform mixture. The shape of the flowing particles in cross section of the tubular reactors shown in Figs. 10 (a) and (b) are not adequate because the particles flows locally in one side of the reactor 150. Suitable shape of the flowing particles for rapid mixture is that having a large outer surface. The cylindrical shape formed by the flowing particles as shown in Fig. 14 has the largest outer surface and thus is found to be suitable for rapid mixture. From view of the foregoing, the particles flowing in a cylindrical form are most suitable for rapid uniform mixture in a tubular reactor while controlling an amount of the particles to be mixed.

The above and other features and advantages of the invention will be better understood from reading the following detailed description with reference to the accompanying drawings.

FIG. 1 is a schematic view of an apparatus embodying the invention;
 FIG. 2 is a schematic view of a modified form of apparatus embodying the invention;
 FIG. 3 is a schematic view of a further modified form of apparatus embodying the invention;
 FIG. 4 is a schematic view of an upper portion of a tubular reactor of the inventive apparatus;
 FIG. 5 is a schematic view of a modified form of the same;
 FIG. 6 is a sectional view of a tubular reactor illustrating a state that a fluid is sprayed toward particles;
 FIG. 7 is a schematic view of a further modified form of apparatus embodying the invention;
 FIG. 8 is a schematic view of a further modified form of apparatus embodying the invention;
 FIG. 9 is an explanatory view showing particles flowing downwardly in a tube;
 FIGS. 10 (a), (b) and (c) are cross-sectional views of the tube of FIG. 9 showing the particles flowing locally in the tube;
 FIG. 11 is an explanatory view showing particles flowing downwardly in a tube;
 FIG. 12 is a cross-sectional view of the tube of FIG. 11 showing the particles flowing locally in the tube;
 FIG. 13 is an explanatory view showing particles flowing downwardly in a tube;
 FIG. 14 is a cross-sectional view of the tube of FIG. 13 showing the particles flowing downwardly in the tube;
 FIG. 15 is a sectional view of an apparatus embodying another aspect of the invention.
 FIG. 16 is a cross sectional view taken along the line A - A of FIG. 15.
 FIG. 17 is a cross sectional view taken along the line B - B of FIG. 15.
 FIG. 18 is a schematic view of main portion of an apparatus according to the invention.
 FIG. 19 is cross sectional view taken along the line C - C of FIG. 18.

Referring now to the drawings, particularly to FIGS. 1, there is shown an apparatus 101 for mixing the fluid of a feed stock such as a heavy oil and catalyst particles enabling the heavy oil to be vaporized in a tubular reactor 102.

The reactor 102 is a vertically extending cylindrical tube (vertical downflow-type reactor) provided in the upper portion with a port 103 through which the catalyst particles are supplied. The mixing apparatus 101 is provided on the reactor 102 with a moving bed forming section 105 for forming a cylindrical high-velocity moving bed 104 as shown in FIG. 4 by dropping the catalyst particles from the port 103 successively while distributing the same circularly.

The forming section 105 is not restricted to the construction as long as the high-velocity moving bed 104 can be formed in the reactor 102. For instance, in FIG. 1 the particles are formed into a moving bed by fluidization using air or gas. The moving bed forming section 105 comprises a controlling section 107 for adjusting the density of a moving bed 106 formed by fluidizing the catalyst particles and a cylindrical forming tube 109 having a through passage 108 where the particles are formed into a cylindrical shape, extending vertically.

The controlling section includes a chamber 110 extending vertically and having a cross section in a circular, polygonal, rectangle or cylindrical in shape. The chamber 110 is provided in the inner lower portion with a porous plate type dispersing means using a gas and a hybrid-type dispersing means. Provided in the chamber 110 in FIG. 1 is a porous plate 111. Furthermore, in the middle upper portion the chamber 110 is provided with a feed port 112 communicated with a feed pipe 113 through which to feed the particles heated at elevated temperatures such as a catalyst of silica almina particles having a particle size of 1 - 500 μm and heated at a temperature of 450 - 700°C. Mounted below the feed port 112 and above the middle portion of the chamber is a receptacle 114 receiving the particles supplied from the feed pipe 113. The particles overflow the receptacle 114 and then fall onto the porous plate 111. The bottom portion of the chamber 110 is connected with a fluid gas feed pipe 115 supplying moving gas such as air or inactive gas through

the porous plate to the chamber 110 so as to fluidize the particles on the plate 111 to form the fluidized bed 106.

The chamber 110 is connected concentrically at the center of the bottom with the cylindrical forming tube 109 extending through the porous plate 111. The cylindrical tube 109 has a dual wall structure comprised of an inner tube 116 and an outer tube 117 arranged in concentric relation forming therebetween a tubular passage 108. The inner tube 116 extends vertically in the neighborhood of the receptacle 114 and further extends therefrom horizontally so as to penetrate the side wall of the chamber 110 and connect with a heavy oil supplying device (not shown) such as a pump. The outer tube 117 extends through the porous plate 111 to a certain level which is higher than where the porous plate 111 is located and acts as a weir so that the fluidized bed is increased in height and then surged into the through passage 108, resulted in the formation of a high-velocity moving bed while passing through the outer tube 117. Needless to mention, the length of the outer tube 117 is determined by that of a high-velocity moving bed determined arbitrary.

Alternatively, the chamber 110 may be constructed as shown in FIG. 2. More specifically, a feed pipe 119 for feeding the particles may be connected with a side wall of the chamber 110 so as to feed the particles directly onto the porous plate 111 and the inner tube 116 may extend linearly so as to penetrate the top wall of the chamber 110. Even with such a construction, the fluidized bed 106 can be formed.

As shown in FIG. 1, the lower ends of the inner and outer tubes 116 and 117 are merged with an inner and outer peripheral walls 120 and 121 respectively, dividing the feed port 103 into sections through which the particles in the form of the high-velocity moving bed 104 enter into the reactor 102. The diameter of the outer tube 117 is determined depending upon the feed rate of the particles and may be formed to be smaller than the diameter of the reactor 102 as shown in FIGS. 1 and 2. Alternatively, the outer tube may have a larger diameter than that of the reactor tube in the case where the particles are fed in a large amount as shown in FIG. 3. The diameter of the inner tube 116 is also selective depending upon the feed rate of the particles.

As shown in FIGS. 1 through 3, an external fluid feed section 122 is provided externally around the outer periphery of the outer walls 121 and above the reactor tube 102. The fluid feed device sprays a fluid over the whole outer periphery of the cylindrical moving bed 104. Another fluid feed section 123 is provided on the inner peripheral wall 120 to spray a fluid over the whole inner periphery of the cylindrical moving bed 104. These fluid feed sections 122 and 123 may have any type of construction as long as they can spray a liquid feed stock such as a heavy oil over the inner and outer peripheral surfaces of the moving bed 104 and thus may be constructed as shown in FIGS. 4 and 5.

FIG. 4 illustrates that a feed stock is sprayed by a hydraulic spraying system using blasting nozzles, effected by increasing linear speed thereof. In this system, there is not used an atomizing steam used as a spraying medium. More specifically, a circular feed chamber 125 for feeding a feed stock is provided integrally with the reactor 102 in surrounding relation to the outer peripheral wall 121 thereof. The circular feed chamber 125 may be provided separately from the reactor 102. The circular feed chamber 125 is provided on its inner wall (outer peripheral wall 121 of the reactor 102) with a plurality of external spraying nozzles 126 through which a feed stock is sprayed toward the cylindrical moving bed 104. These nozzles are disposed, spaced apart at certain intervals. The external spraying nozzles 126 are not restricted to their spraying angle as long as a fluid can be further fined by impact upon collision with the particles. Preferably, the nozzles are arranged to spray a liquid at an angle of 15 - 75° downwardly with respect to a horizontal direction. In FIG. 4, the spray angle is 45° downwardly with respect to a horizontal direction. The number of the spraying nozzles 126 is selective if a liquid can be sprayed over the entire outer surface of a moving bed.

The inner peripheral wall 120 is substantially the lower part of the inner tube 116 which serves also as a cylindrical feed chamber 127 for feeding a feed stock. The lower end (tip) of the inner peripheral wall is in a conical shape, directed downwardly and provided with a plurality of internal spraying nozzles 128 through which the feed stock is sprayed toward the cylindrical moving bed 104. The spraying nozzles 128 are equally spaced in the circumferential direction of the tip of the inner peripheral wall to spray the feed stock over the entire inner surface of the moving bed 104. There is no limitation to the spray angle of the internal spraying nozzles 128 if the sprayed material can be further fined by impact occurring upon collision with the particles. Preferably the internal nozzles are disposed to spray the feed stock at an angle of 15 - 75° downwardly with respect to a horizontal direction. In FIG. 4, the spraying angle of the internal nozzles is set at 45°. The number of the internal nozzles is selective as long as a feed stock can be sprayed over the entire inner surface of the moving bed 104. The ratio of the external fluid-feed section 122 to the internal fluid-feed section 123 in spraying rate is not restricted if a feed stock can be sprayed over the entire inner and outer surfaces of the moving bed 104. Preferred ratio is the range of 1 : 1 to 3 : 1.

The external and internal fluid-feed sections 122 and 123 are surrounded by a thermal insulating member 130 which prevents a feed stock from coking caused by heat conduction from the catalyst particles heated at a temperature of 450 - 700°C. The insulating member 130 is not restricted to its construction if it can prevent a feed stock from being adversely affected by the particles heated at elevated temperatures. For instance, heat insulation may be effected with the use of a conventional insulating material such as air or steam. FIG. 4 illustrates that heat insulation is effected by flowing steam into rooms formed on the upper and lower portions of the cylindrical feed chamber 125. More specifically, an upper circular steam-feed chamber 131 is disposed circumferentially on the upper portion of the feed chamber 125 to communicate with a vertically extending small space (clearance) 132 defined between the feed chamber 125 and

the forming tube 109 in surrounding relation thereto. Steam supplied into the steam-feed chamber 131 flows downwardly into the reactor 102 through the small space 132 of which lower end is opened to the port 103 such that the upper portion of the feed chamber 125 is thermally insulated. Furthermore a lower circular steam-feed chamber 133 is disposed circumferentially on the lower portion of the feed chamber 125 to communicate with a horizontally extending small space 134 defined between the steam-feed chamber 133 and the reactor 102. Steam supplied into the steam-feed chamber 133 flows horizontally into the reactor 102 through the small space 134 of which end is opened into the reactor 102 such that the lower portion of the feed chamber is thermally insulated. A vertically extending passage 135 is defined between the inner wall of the inner tube 116 and the outer wall of the feed chamber 127. In other words, the inner tube 116 has a dual structure. Steam is fed downwardly into the reactor 102 through the passage 135 of which lower end is opened into the reactor 102 to thermally insulate the feed stock sprayed through the feed chamber 127.

FIG. 5 shows exemplarily an external spraying nozzle and an internal spraying nozzle used for a method in which a fluid such as a feed stock is sprayed using a medium such as a gas or an atomizing steam. For the sake of brevity, the same parts in FIG. 5 corresponding to those in FIG. 3 are indicated by the same numeral.

An external fluid-feed 122 section in FIG. 5 is different from that in FIG. 4 in that a plurality of spraying nozzles 136 into which the feed stock is directly supplied, are disposed circumferentially at certain intervals to spray the feed stock over the entire outer surface of the moving bed. The spraying nozzle 136 is a type of internal mixing structure in which a feed stock flows through the center the outside of which an atomizing steam flows to the tip of the nozzle to thermally insulate the feed stock.

The internal fluid-feed section 123 in FIG. 5 employs an internal mixing structure in which an atomizer 138 is mounted in an internal mixing chamber 137 to enhance spray effect. The atomizer 138 has a plurality of nozzles 139 disposed circumferentially on its lower tip at certain intervals to spray the feed stock over the entire inner surface of the cylindrically flowing particles. A passage 140 for steam is defined by the inner wall of the inner tube 116 and the outer wall of the mixing chamber 137 to utilize a part of the atomizing steam as a thermal insulating means as well as the external spraying nozzle 136.

There is described hereinafter a method of contact-mixture of a feed stock (heavy oil) and a catalyst of silica alumina particles heated at a temperature of 450 - 700°C using the apparatus 101.

Catalyst particles are supplied from a feed pipe 113 and fall successively through a feed port 112 onto a receptacle 114 from which overflowed catalyst particles further fall onto a porous plate 111. The catalyst particles collecting on the porous plate 111 densely in the circumferential direction can be uniformly dispersed toward a spot of a lower density while being moving to be formed into the circular bed.

The fluidized bed increased in height flows beyond an outer tube 117 and into a through passage 108 from the all circumferential direction of the outer tube and formed into a cylindrical high-velocity moving bed 104 while passing via the through passage 108. The fluidized bed then enters through a port 103 into a reactor 102.

A feed stock is sprayed by external spray nozzles 126 and internal spray nozzles 128 over the upper outer and inner surfaces of the moving bed 104 entirely in the circumferential direction thereof as shown in FIG. 6. Due to a thermal insulating means 130 provided on the outsides of the external and internal spraying nozzles, the feed stock sprayed therethrough is insulated from the heat exerted from the heated catalyst particles (450-700°C) and thus free from coking. The sprayed feed stock is collided with the catalyst particles forming the cylindrical moving bed 104 and then sputtered in the form of further fined particles by impact upon the collision. Therefore, the mixture of the catalyst particles and the heavy oil can be conducted effectively. The resulting mixture moves downwardly in the reactor 102.

The inventive apparatus makes possible the increase of the recycle ratio of a catalyst to oil in the reactor 102 up to 50:1 which is several times greater than that (5 - 8:1) of a fluid catalytic cracking apparatus having a conventional reactor using a rising type of high-velocity moving bed.

In the inventive apparatus, the contact of a feed stock and particles can be effected efficiently by spraying the feed stock from both of the outer and inner peripheries of a cylindrical moving bed of the catalyst particles to be contacted and mixed therewith. Furthermore, the feed stock can be mixed rapidly and uniformly with the particles because the feed stock is further fined by impact upon contact with the cylindrically flowing particles. Due to the capability of spraying a feed stock from the outer and inner peripheries of the cylindrical particle bed, the proportion of the particles to be used can be increased such that the weight ratio of particles to a feed stock is up to 50:1.

Therefore, the contact reaction can be conducted uniformly for an extremely short period of time due to the capability of reduction in time (approximately 0.1 to 1.5 second) for contacting a feed stock with catalyst particles such that unfavorable excess cracking reaction can be avoided, leading to the capability of the production of a gasoline enhanced in quality.

Shown in FIG. 7 is a modification of the controlling section 107 in which dispersion is conducted merely by falling freely the catalyst particles, not by fluidization.

More specifically, the controlling section 107 includes a vessel 142 which is in the form of a vertical cylinder having an feed port 112 connected with a feed pipe for feeding particles on its upper portion and a receptacle 114 for receiving the particles in the internally upper portion and below the feed port 112. The vessel 142 has a lower part in the form

of a hopper reduced in diameter progressively toward the bottom. Provided on the bottom is a discharge port 143 connected with the tip end of an outer tube 117 constituting a moving bed forming tube 109. An inner tube also constituting the forming tube 109 extends in close proximity of the receptacle 114 and then extends curvedly in a horizontal direction to penetrate the side wall of the vessel 142. Between the inner tube 116 and the vessel 142, there is defined a vertical cylindrical passage 144 through which particles pass downwardly. In the passage 144, a plurality of baffles 145 and 146 are disposed at certain intervals in the longitudinal direction to alter the flow direction of particles so as to disperse them uniformly in the circumferential direction. The baffles 145 and 146 are not restricted to their shapes and number if they can alter the flow direction of the particles and disperse the particles uniformly in the circumferential direction. In the embodiment in FIG. 7, two circular baffles 145 and 146 are disposed at a certain interval to be spaced apart in the vertical direction. More specifically, the circular upper baffle 145 is inclined downwardly toward the inner radial direction and fixed at the outer peripheral edge to the inner wall of the vessel 142, defining a through-opening between the inner peripheral edge and the inner tube 116. The lower circular baffle 146 is inclined downwardly toward the outer radial direction and fixed at the inner peripheral edge to the outer wall of the inner tube 116, defining a through-opening between the outer peripheral edge and the inner wall of the vessel 142. A gas may be supplied through the inlet 112 together with particles. In the case of supplying catalyst particles in a small amount, they can pass smoothly through the forming section 109 by their own weight without feeding a gas. However, if an attempt of feeding the catalyst particles in a large amount without feeding a gas is made, a pressure loss occurs in the forming section 109, leading to repletion of the vessel with the catalyst particles due to the provision of the plurality of the baffles. Therefore, the supplement of pressure is required to overwhelm the pressure loss in the forming section 109 by feeding a gas together with a catalyst. Furthermore, the reason for feeding a gas is to facilitate to uniform the density of particles.

With this construction, particles overflowing the receptacle 114 fall onto the upper baffle 145 and move inwardly in the radial direction to the peripheral edge from which the particles fall through the opening onto the lower baffle 146. The particles on the lower baffle move outwardly in the radial direction to the peripheral edge from which the particles fall via the through opening onto the lower portion of the hopper. In this way, the particles are dispersed uniformly in density in the radial direction as they move over the baffles 145 and 146.

The particles uniformed in density flow successively into the through passage 108 and formed into a high-velocity moving bed in a cylindrical shape while passing through the through passage 108 in the above-described manner.

The particles in the form of the cylindrical moving bed are brought into contact with a feed stock fed by spraying from its outer and inner peripheries so that the contact can be effected efficiently. Furthermore, the sprayed feed stock is further fined by impact upon the contact, leading to the more efficient contact so that the uniform mixture of the feed stock and particles can be conducted rapidly.

FIGS. 8 shows a modification of the apparatus shown in FIG. 7 which is different in that the upper portion 147 of a reactor 102 is widened in diameter to be the same as that of a vessel 142 and provided with an external fluid feed section 122 from which a feed stock is sprayed in a horizontal direction, not at an angle of 45° downwardly.

Referring now to FIG. 15 - 19, there are shown another embodiments of the inventive mixing apparatus 101.

The mixing apparatus 201 shown in FIG. 15 comprises essentially a dispersing device 202, a plurality of standpipes 203 each having an upper portion extending vertically through the bottom of and up to the upper section of the dispersing device 202, a mixing section 204 into which catalyst particles flow downwardly from the standpipes each having the lower portion into the mixing section 204, a plurality of plates 205 disposed in the mixing section 204 and below the lower part of the standpipes to disperse the particles fed therefrom in the radial direction and a fluid-feed chamber 206 disposed in the mixing section to spray a fluid such as a feed stock (heavy oil) so as to mix the same with the particles.

The dispersing device 202 is not restricted to the construction if it can distribute particles uniformly into the standpipes. In the embodiment shown in FIG. 15, fluidized bed is used to distribute the particles.

The distributing device 202 includes a chamber 207 which is vertical and may be round, polygonal or rectangle in a cross-section. The chamber 207 in FIG. 15 is cylindrical and provided in the lower portion with a porous-plate type distributor or a pipe grid distributor. In this embodiment, a porous plate 208 is employed. The side wall of the chamber 207 is connected with a feed pipe for feeding particles of such as a silica-alumina catalyst having a diameter of 1-50 µm and heated at a temperature of 450-700°C to the porous plate. The lower portion of the chamber 207 is connected with a fluidized gas feed pipe 210 for feeding a fluid gas such as steam, air or inactive gas through the porous plate 208 into the chamber 207 to fluidize the particles so as to form a fluidized particle bed 211. Each of the plurality of standpipes 203 extends vertically through the bottom of the chamber 207 and the porous plate 208 and has an upper tip extending as far as the mid-section of the chamber 207.

Although not restricted, the standpipes are disposed 3 to 30, preferably 3 to 7 in numbers. The standpipes should be arranged at certain intervals in the chamber 207. In FIG. 16, for instance, there are disposed seven pieces of the standpipes, six of which are arranged to be spaced equally apart (60°) in the circumferential direction and one of which is arranged to be on the center. The diameter of each stand pipe 203 is selective depending upon the feed rate of particles. However, needless to mention, under the conditions that the diameter of a reactor 212 described hereinafter and the number of the stand pipes are constant, the diameter thereof is increased with the feed rate of particles in-

creased and decreased with the feed rate of the same reduced. The flow ratio of a catalyst to an oil is in the range of 5 - 50, preferably 20 - 30. The ratio less than 5 would result in an insufficient reaction due to a reduction in contacting time. The ratio exceeding 50 would involve a problem such as pressure loss and erosion.

Disposed below the chamber 207 is a mixing chamber 204 for mixing a feed stock and the catalyst particles into which the lower tip of each of the stand pipes extends as far as the upper portion of the mixing chamber 204. Therefore, the fluidized particles pass through the mixing chamber 204 downwardly. The mixing chamber 204 is in the form of a cylinder and connected at the lower portion with a reactor 212 (vertical downward-flow type reactor) having the same diameter as that of the mixing chamber.

The plurality of plates 205 for dispersing the particles flowing from the stand pipes 203 in the circumferential direction are disposed therebelow and in the middle section of the mixing chamber 204. These plates 205 are arranged at the same horizontal level. Although not restricted, the plates may be in the shape of a disk having a diameter which is the same as or larger than that of the lower end of the stand pipe or having the center recessed lower than the level of the outer periphery, a dish-shape disk or a cone.

Furthermore, below these plates there are disposed another plurality of plates 213 for further dispersing the particles falling down from the dispersing plates 205, at the same horizontal level. These dispersing plates 213 should be arranged in such a position that the particles flow densely, for which instance the dispersing plates 213 are arranged below the spaces between the dispersing plates 205 as shown in FIG. 15. The dispersing plates may be those which are the same as or different from the dispersing plates 205 located in the upper stream. In FIG. 15, the dispersing plates 205 and 213 are arranged in a single tier, respectively. Preferred number of tiers is within the range of 1 to 5, because too many tiers could increase mixing efficiency but result in pressure loss.

A fluid-feed chamber 206 is provided in the mixing chamber in surround relation to the outer periphery of the stand pipes 203 to spray a feed stock such as a heavy oil. As long as the fluid-feed chamber 206 sprays a feed stock over the entire outer periphery of particles flowing in the form of such as a cylinder, the chamber 206 is not restricted to its structure. The spraying angle is selective from 0 (horizontal direction) to 90°C (vertical direction) as shown in FIGS. 15 and 18. More specifically, the fluid-feed chamber 206 in FIG. 15 is constructed to spray a feed stock downwardly in close proximity of and in parallel relation to the outer periphery of the particles flowing cylindrically from the stand pipes so that the sprayed feed stock comes into contact with particles after being dispersed by the plates 205 and 213.

In FIG. 18, the fluid-feed chamber 206 sprays a feed stock at an angle of 0°, i.e. in parallel with respect to a horizontal level by using a spraying medium such as gas and steam.

The fluid-chamber 206 is also provided with an insulating means 214 as shown in FIG. 18. In the upper portion of the mixing section 204, there is provided with trays 215 - 218 which contain a steam for thermal insulation, a steam for spraying, a feed stock and a steam for thermal insulation and spraying, respectively. These trays 215 - 218 are arranged in vertically superposed relation to one after another and in surround relation to the stand pipes. Therefore, the stand pipes extend through these trays 215 - 218. Between the superimposed trays 215 - 218 and the outer periphery of each of the stand pipes, there is provided small cylindrical spaces or clearances 219 the upper portion of which is communicated with the thermal insulation steam tray 215 so that a thermal insulating steam flows downwardly along the outer periphery of each of the stand pipes 202 so as to effect thermal insulation of a feed stock from heat of the stand pipes.

Disposed below the thermal-insulating and spraying steam tray 218 is a partition 220 for thermal insulation extending in a horizontal direction and formed to be directed to the lower ends of the stand pipes. More specifically, this partition 220 is in the form of a disk provided with circular openings at the positions in conforming with the lower ends of the stand pipes. A clearance 221 is provided between the partition 220 and the thermal insulating and spraying steam tray 218 such that the steam therefrom flows through the clearance 221 inwardly in the radial direction to thermally insulate the inside of the mixing section and the feed stock fed from the feed stock tray 217. The insulating means 214 is constituted by the trays 217 and 218. The insulating means 214 is not restricted to its construction as long as it can thermally insulate a feed stock from the heat of the stand pipes.

A cylindrical spraying chamber 222 is provided around the space 219, the upper portion of which chamber is communicated with the spraying steam chamber 216 so that the steam of a spraying medium therefrom can flow downwardly through the chamber 222 at high velocity. A multiplicity of spraying nozzles 223 are provided on the side wall of the feed stock tray 217 so that the feed stock therefrom is sprayed into the spraying chamber 222 to be mixed with steam. The resulting mixture collides with the thermal insulating partitions 221 and then flows horizontally over the entire outer periphery of the particles fed from the stand pipes. The mixture is sprayed at an angle ranging from 0° (horizontally) to 90° (vertically), preferably from 0° to 45°. This angle can be varied by altering the angle of the partition 220. In the embodiment shown in FIG. 18, the mixture is sprayed at an angle of 0°, i.e. horizontally. As shown in FIG. 19, a plurality of spraying nozzle 223 are disposed at certain intervals in the circumferential direction to spray a feed stock entirely to the spraying chamber. The number of tiers on which each plurality of spraying nozzles 223 are disposed, spaced equally apart vertically, is selective within the range between 1 and 6, preferably 1 and 3.

The operation conducted by using the apparatus in FIG. 15 is now described hereinbelow.

5 Catalyst particles are fed continuously onto the porous plate 215 through the feed pipes 209 and then fluidized by fluid gas to be formed into the fluidized bed 211. By forming the fluidized bed 211 in this way, the particles fed excessively on a particular spot can be dispersed toward a part on which has less particles while being fluidized so that the particles can be dispersed in uniform density in a horizontal direction.

10 As the fluidized particles bed becomes increased in height, a part of the particles flows into the stand pipes 203 beyond the upper edges thereof from the all circumferential direction. Since the particles uniformed in density in a horizontal direction in such a manner are increased in height and then flows into the plurality of stand pipes, the particles in an equal amount can be distributed into each of the stand pipes.

15 The particles in each of the stand pipes flow downwardly through the lower opening to the mixing chamber 204.

10 The particles further flow down consecutively in the mixing chamber 204. The particles thus flow in the form of a cylinder although depending on the amount of the particles. Therefore almost all the particles collide with the dispersing plates 205 and then dispersed in the outer radial direction. For example, in the case of using the plate 205 in the form of a disk or a dish, the particles are piled up thereon in the form of a cone widened downwardly and having an angle of response of around 20° as indicated by dot-lines in FIG. 18 so that the particles falling onto the piles fall along the slopes thereof outwardly in the radial direction. In the case of using the disk or dish like plates 205 having the depressed center, the particles collecting in the middle of the plates 205 function as a cushion to absorb the impact exerted by the particles falling from the stand pipes, leading to an advantage with respect to erosion.

20 Therefore, the dispersion of the particles is conducted in an effective manner by dispersing the particles falling from the plurality of the stand pipes with the corresponding plates outwardly in the radial direction.

25 In the embodiment shown in FIG. 15, a feed stock is sprayed vertically from the fluid-feed chamber 206 in close proximity of and in surrounding relation to the outer periphery of the particle fed cylindrically from each of the stand pipes. Whereupon, the feed stock can be sprayed without coking due to the insulating means 214 provided in the spraying chamber 206 which can thermally insulate the feed stock from the catalyst particles heated at a temperature of 450 - 700°.

30 The feed stock sprayed in this manner is then collided with the particles dispersed outwardly in the radial direction and further finely scattered by impact upon the collision so that the feed stock can be mixed uniformly and rapidly with the particles. The resulting mixture is improved in contact efficiencies and the vaporization of the feed stock can be effected sufficiently. Furthermore, due to the plurality of the dispersion plates 205 and 213 provided in a multilayer, the particles are further dispersed and come to contact (collide) with the feed stock, resulting in further enhancement of contact efficiency leading to the mixture effected in a satisfactory manner. The resulting mixture flows downwardly into the reactor 212.

35 In the fluid-feed chamber 206 constructed as shown in FIG. 18, a steam fed from the spraying steam tray 216 flows into the upper portion of the spraying chamber 222 and then flows downwardly thereinside at high velocity and at the same time the feed stock in the feed stock tray 217 is sprayed into the spraying chamber 222 to be mixed with the steam therein. The mixture is brought into collision with the partition 221 and sprayed together with the steam fed from the thermal insulating and spraying steam tray 218 over the entire outer periphery of the particles fed in the form of a cylinder from each of the stand pipe in a horizontal direction. Namely, the feed stock is sprayed at right angle with respect to the flow direction of the particles fed cylindrically from each of the stand pipes 203.

40 The feed stock sprayed in this manner is further fined by the collision with the particles fed cylindrically and then flows downwardly after being scattered to the neighborhood of the outer periphery of the particles. The particles are dispersed in the outer radial direction by the dispersing plates 205 and collide again with the fined feed stock so that the feed stock is further finely scattered, leading to an efficient dispersion of the feed stock.

45 Therefore, the catalyst particles and the feed stock can be mixed uniformly and rapidly and contacted each other efficiently because the catalyst particles are distributed evenly to the plurality of stand pipes 203 and dispersed by the dispersing plates after passing through the stand pipes 203 and the feed stock comes into contact with the dispersed particles and then finely scattered. The inventive apparatus is applicable to the case where the catalyst particles is used in the larger proportion to the feed stock, maximum 50 in the ratio therebetween.

50 Furthermore, the contact reaction can be conducted uniformly for an extremely short period of time due to the capability of reduction in time (approximately 0.1 to 1.5 second) for contacting a feed stock with catalyst particles such that unfavorable excess cracking reaction can be avoided, leading to the capability of the production of a gasoline enhanced in quality.

55 The invention will be further described by way of the following examples which are provided only for illustrative purposes.

Experiment 1

There were used five types of mixing apparatuses in the form as shown FIGS. 1, 2, 7, 8 and 3 each of which was designated as Apparatus A, B, C, D and E respectively. The principal dimensions of each apparatus are shown in Table

1

There were used catalyst particles generally used in a flowing catalytic cracking apparatus producing a gasoline from a heavy oil. The catalyst was 63 microns in an average particle size and 0.85 g/cm³ in a bulking density. Air at normal temperature was used as a fluid to be sprayed instead of a feed stock.

5

The experimental conditions were established on the assumption that mixing and gasification had just completed by spraying a feed stock to catalyst particles heated at a temperature of 600°C but the reaction had not occurred yet. The experimental conditions based on the assumption were changed in a feed rate of catalyst from 10 kg/min to 100 kg/min and a feed rate of air from 5 m³/h to 50 m³/h. The feed rate of air was adjusted by varying the spraying ratio of an internal spraying nozzle to an external spraying nozzle. These apparatuses are made from vinyl chloride. The state of mixture was observed by using a video camera and by viewing.

10

Example 1

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There were conducted the experiments using Apparatus A under the various conditions mentioned above. A fluidized bed of the catalyst fed at a feed rate of 30 kg/min flowed beyond the upper edge of the forming section and fell freely therethrough. The feed rate exceeding 30 kg/min led to a fluidized bed increased in height and as a result thereof the particles flowed beyond the edge of the forming section were forced to flow into the forming section by the air supplied to disperse the fluidized bed. This is presumably caused by pressure loss in the forming section. However, both particles fed at increased feed rate and reduced feed rate after passing through the forming chamber were formed into a well-cylindrical shape. It is observed that the particles flowed locally toward the center of the reactor when the mixture was conducted by using only the external nozzles. On the contrary, when only the internal nozzles were used, it was observed that the particles collided with the inner wall of the reactor. The mixability was most excellent when the spray ratio of the external nozzles to the internal nozzles was 2 to 1. The mixability was improved with an increase of the feed rate of air.

20

Example 2

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There were conducted the same experiments as those of Example 1 using Apparatus B. As well as Apparatus A, Apparatus B was excellent in formability of the particles into a cylindrical shape and in mixability of the particles and the air. The cylinder of the particles formed by Apparatus A had a diameter of 60 mm while that formed by Apparatus B had 70 mm. However, there was not observed the difference in the mixture thus obtained resulted from the difference in diameter.

35

Example 3

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There were conducted the same experiments as those of Example 1 using Apparatus C. Apparatus C was provided in the controlling section for adjusting the density of the particles with baffles to distribute the particles uniformly in density and constructed so that the particles freely fall through the forming section. In this connection, the catalyst particles started accumulating in the controlling section when fed at a rate exceeding 20 kg/min. Whereas when fed at a rate increased up to 30 kg/min the catalyst particles filled the control section and passed through the moving bed forming section with their own weight increased with the accumulated particles increased in height. However, this was able to be avoided by introducing air from somewhere in the middle portion of the feed pipe. In both cases, the particles were formed into a well cylindrical shape and mixed with the air excellently.

45

Example 4

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The experiments were conducted using Apparatus D. In the experiment conducted to observe the mixability of the particles and the air, the external spraying nozzles were only used. The external spraying nozzles were set to spray air in a horizontal direction differently from those of the other apparatuses. The particles were not mixed with the air well because they flow locally along the center portion of the reactor.

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Example 5

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There were conducted the same experiments as those of Example 1 using Apparatus E which was increased in diameter of the cylindrical moving bed-forming section so as to be deal with a situation that the catalyst particles are increased in feed rate. In this apparatus, the particles were not increased in level in the chamber even though the feed rate thereof was increased up to 100 kg/min and thus was able to pass smoothly through the forming section beyond the edge of the outer tube constituting the forming section. As well as Example 1, the particles were formed into a well

cylindrical shape and mixed with the air excellently

Experiment 2

5 The apparatuses used for this experiment were two-dimensional model. Two-dimensional models B, C and E correspond to the apparatuses shown in FIGS 2, 7 and 3. The dimensions of each of the two-dimensional models were one and half times larger than that of the respective corresponding apparatuses and 10 mm in thickness. The spraying nozzles were disposed four in total number. Two external spraying nozzles were arranged in pairs of oppositely oriented two internal spraying nozzles. All of these spraying nozzles were disposed to spray at an angle of 45° downwardly with respect to the flow direction of the particles. The principal dimensions of each of the two-dimensional models are shown in Table 2.

Example 6

15 The shape of the cylindrically flowing particles and the mixability of the particles and the air in the reactor were observed using Model B with varied feed rates of the catalyst and the air. Actually the cylindrically flowing particles formed in this model were in the form of a quadratic prism but referred to as "cylindrical" for the sake of convenience. It was observed that the cylindrically flowing particles tended to be increased in density of the outer periphery when fed at a low rate. The mixability in the reactor was extremely improved when the air feed ratio of the external spraying nozzles and the internal spraying nozzles was 1:1.

Example 7

25 There were conducted the same experiments as those of Example 6 using Model C. Which was provided with baffles to uniform the density of the particles. Due to the provision of the baffles, the particles were dispersed uniformly in density and thus formed into a well cylindrical shape as well as Example 6. The mixability in the reactor was also excellent as well as Example 6.

Example 8

30 There were conducted the same experiments as those of Example 6 using Model E. This model corresponds to Apparatus E having the forming zone of which diameter was larger than that of the reactor to deal with a situation that the particles were fed at a extremely high rate. The particles thus formed cylindrically had a larger diameter than that of the reactor, whereby the cylindrical particles were increased in density at the outer periphery when the spraying ratio of the external spraying nozzles and the internal spraying nozzles was 1:1. The mixability was improved with the spraying rate of the external spraying nozzles increased gradually. With further increase of the spraying rate, the mixability was deteriorated. Therefore, it was observed that there existed an optimum in the spraying ratio of the external spraying nozzles and the internal spraying nozzles. The optimum ratio was substantially 1.5:1. The mixability was excellent at this ratio.

Experiment 3

40 There was used an apparatus (Apparatus F) in the form as shown in FIG. 18 which was made from transparent vinyl chloride. The principal dimensions of this apparatus were shown in Table 3.

45 There were used particles of a catalyst generally used in a flowing catalytic cracking apparatus producing a gasoline from a heavy oil. The catalyst was 63 microns in an average particle size and 0.85 g/cm³ in a bulking density. Air at normal temperature was used as a fluid to be sprayed instead of a feed stock.

50 The experimental conditions were established on the assumption that mixing and gasification had just completed by spraying a feed stock to catalyst particles heated at a temperature of 600°C but the reaction had not occurred yet. The experimental conditions based on the assumption were changed in a feed rate of catalyst from 50 kg/min to 350 kg/min and a feed rate of air from 20 m³/h to 120 m³/h. The air was fed by from the second, third and forth spraying nozzles arranged vertically in tiers with the feed rate of each of the nozzles varied. The mixability was observed by using a video camera and viewing.

55 Example 9

There were conducted the above-described experiments using Apparatus F and the results thereof were as follows:

(1) It was observed that the catalyst particles from the dispersing device flowed uniformly into the stand pipes disposed seven in number

(2) The mixability was fairly excellent due to the provision of the dispersing plates although the air was only fed from the feed chamber but not fed from the tray.

5 (3) The dispersion of the particles was improved with the feed rate of air from the tray increased

(4) Under the conditions where the feed rate of air from each of the nozzles was constant, the mixability was improved with the feed rate of air from the forth nozzles increased

Example 10

10 The experiments were conducted using the two-dimensional model of Apparatus F of which primary dimensions were the same as that of Apparatus F and were 1 cm in thick

15 The feed rates of particles and air were one fifteenth of those in Example 9 to be conformity with the ratio of the sectional area of the Apparatus F to that of the model. The mixability was observed by using a video camera and by viewing as well as Example 9. The results were as follows:

20 (1) The particles from the feed chamber were flow uniformly into the stand pipes disposed seven in number. However, the particles mostly tended to flow the outside but not the center of the stand pipes when fed at a low rate.

(2) Although the effect of the dispersing plates arranged in two tiers was recognized, the mixability was not satisfactory when the air was fed only from the feed chamber but not from the tray. The mixability was extremely improved with the feed rate of air from the tray increased.

25 (3) The mixability was improved with the feed rate of air from the forth tray increased as well as Example 9.

(4) The particles passed through the stand pipes fell onto the dispersing plates and were formed into a mountain having a response angle of around 20°. The dispersing plates used in this example were in the form of a shallow tray. The particles accumulated on the plates played a role as a cushion in absorbing the impact caused by the particles falling from the stand pipes. This is advantageous to avoid erosion.

TABLE 1

| Dimensions of Apparatuses | | | | | |
|--|-------------|-------------|-------------|--------------|-------------|
| | Apparatus A | Apparatus B | Apparatus C | Apparatus D | Apparatus E |
| Diameter of Controlling Section mm | 200 | 200 | 100 | 100 | 320 |
| Length of Controlling Section mm | 300 | 300 | 250 | 250 | 300 |
| Diameter of Outer Tube mm | 60 | 70 | 70 | 70 | 100 |
| Length of Outer Tube mm | 100 | 100 | 50 | 50 | 100 |
| Diameter of Inner Tube mm | 30 | 40 | 40 | 40 | 60 |
| Diameter of Spray Nozzle for Feed Stock mm | | | | | 100 |
| Diameter of Reactor mm | 80 | 80 | 80 | 80 | 80 |
| Diameter of External Nozzle mm | 2 | 2 | 2 | 2 | 2 |
| Number of External Nozzle | 32 | 32 | 32 | 32 | 32 |
| Diameter of Internal Nozzle mm | 2 | 2 | 2 | 2 | 2 |
| Number of Internal Nozzle | 16 | 16 | 16 | 16 | 16 |
| Downward Angle of Spraying Feed Stock degree | 45 | 45 | 45 | Horizontal 0 | 45 |

TABLE 2

| Dimensions of Two-Dimensional Model Mixing Apparatus | | | | |
|--|--|-------------------------|-------------------------|-----|
| | Two-Dimensional Model B | Two-Dimensional Model C | Two-Dimensional Model E | |
| 5 | Diameter of Controlling Section mm | 300 | 150 | 320 |
| 10 | Length of Controlling Section mm | 300 | 250 | 300 |
| 15 | Diameter of Outer Tube mm | 100 | 100 | 150 |
| 20 | Length of Outer Tube mm | 150 | 70 | 150 |
| 25 | Diameter of Inner Tube mm | 60 | 50 | 90 |
| 30 | Diameter of Spray Nozzle for Feed Stock mm | | | 150 |
| 35 | Diameter of Reactor mm | 120 | 120 | 120 |
| 40 | Thickness of Mixing Section and Reactor mm | 10 | 10 | 10 |
| 45 | Diameter of External Nozzle mm | 3.5 | 3.5 | 3.5 |
| 50 | Number of External Nozzle | 2 | 2 | 2 |
| 55 | Diameter of Internal Nozzle mm | 3.5 | 3.5 | 3.5 |
| 60 | Number of Internal Nozzle | 2 | 2 | 2 |
| 65 | Downward Angle of Spraying Feed Stock degree | 45 | 45 | 45 |

TABLE 3

| Dimensions of Apparatus | | |
|-------------------------|----------------------------------|-----------|
| | | Apparatus |
| 45 | Diameter of Dispersing Device mm | 320 |
| 50 | Diameter of Standpipe mm | 30 |
| 55 | Diameter of Mixing Section mm | 160 |
| 60 | Diameter of Dispersing Plate mm | 30 |
| 65 | Diameter of Reactor mm | 160 |
| 70 | Diameter of Nozzle mm | 2 |
| 75 | Number of Nozzles (16 x 2 x 7) | 224 |

Claims

1. An apparatus (101) for mixing a fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the fluid in a reactor (102) which comprises said reactor (102) having in the upper portion a circular port (103) through which said particles are fed a moving bed forming section (105) disposed on and in communication with said reactor (102) for forming the particles into a cylindrical high-velocity moving bed by falling the particles downwardly into said reactor while dispersing circularly the particles. an external fluid feed section (122) located so as to spray the feed stock over the entire upper outer periphery of the cylindrical moving bed passing through said reactor and an internal fluid-feed section (123) located so as to spray the fluid over the entire upper inner periphery corresponding to said outer periphery of the cylindrical moving bed (104).
2. An apparatus (101) according to claim 1 wherein said fluidized bed forming section (105) comprises a controlling section (107) in which the fluidized bed are formed by fluidizing the particles and adjusted in density by dispersing the particles uniformly in a horizontal direction. a cylindrical forming tube (109) defining therein a through passage (108) and having the upper end extending to the upper portion of the fluidized bed and the lower end connected with said circular port (103) of said reactor.
3. An apparatus (101) according to claim 1 wherein said fluidized bed forming section (105) comprises a controlling section (107) provided with a plurality of baffles (145,146) disposed to be spaced equally apart in a vertical direction to disperse uniformly the particles in a circumferential direction by changing the flow direction of the particle and a cylindrical forming tube (109) defining therein a through passage (108) and having the upper end extending to the upper portion of the fluidized bed and the lower end connected with said circular port (103) of said reactor.
4. An apparatus (101) according to any one of preceding claims 1 through 3 wherein said external fluid-feed section (122) comprises a plurality of external spraying nozzles (126) disposed facing the outer periphery of said circular port and spaced circumferentially at certain intervals to spray the fluid to said moving bed downwardly at an angle of 15 - 75° with respect to a horizontal direction and a plurality of internal spraying nozzles (128) disposed facing the inner periphery of said annular port and spaced circumferentially at certain intervals to spray the fluid to said moving bed downwardly at an angle of 15 - 75° with respect to a horizontal direction.
5. An apparatus (101) according to claims 2 and 3 wherein said cylindrical forming tube (109) has a dual structure comprised of an outer tube (117) through which the moving bed flows and an inner tube (116) through which the feed stock flows.
6. An apparatus (101) according to claim 2 wherein said controlling section includes a chamber (110) provided at lower part with a porous plate (111) through which a fluidized gas is fed by a feed pipe (119).
7. An apparatus (101) according to any one of claims 1 through 4 wherein a thermal insulating means (130) is provided in surrounding relation to said fluid-section to prevent the fluid sprayed thereinto from being affected by the heat of the particles heated at a temperature of over 300 °C.
8. An apparatus (201) for mixing the fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the fluid which comprises a plurality of stand pipes (203) extending vertically a distributing device (202) for distributing uniformly the particles into said stand pipes (203). a mixing section (204) positioned below said distributing device from interior of which said stand pipes (203) extend to the upper interior of said mixing section (204) to feed the particles thereto. a plurality of plates (205) arranged in said mixing section and below said stand pipes for dispersing the particles falling therefrom outwardly in a radial direction and a fluid feed chamber (207) arranged in said mixing section in surround relation to the outer periphery of each of the stand pipes to spray the fluid downwardly in a vertical direction in close proximity of and in surround relation to the entire outer periphery of the cylindrical particles falling from each of the stand pipes so as to collide with the particles after being dispersed by the plates.
9. An apparatus (201) for mixing the fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the fluid which comprises a plurality of stand pipes (203) extending vertically. a distributing device (202) for distributing uniformly the particles into said stand pipes. a mixing section (204) positioned below said distributing from interior of which said stand pipes extend into the upper interior of said mixing section to feed the particles thereto. a plurality of plates (205) arranged in said mixing section and below said stand pipes for dispersing the particles falling therefrom outwardly in a radial direction and a fluid-feed chamber arranged in said mixing section in surround

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relation to the outer periphery of each of the stand pipes to spray the fluid over the entire outer periphery of the cylindrical particles falling from each of said stand pipes

10. An apparatus (201) according to any one of claims 8 and 9 wherein said fluid-feed section is a spraying device for spraying the fluid using a spray medium such as steam and air
11. An apparatus according to claim 9 wherein a disc shape plate (220) is disposed below said stand pipes and has openings just under the lower ends of the stand pipes.
12. An apparatus according to any one of the preceding claims wherein a thermal insulating means (214) is provided in surrounding relation to said fluid-section to prevent the fluid sprayed thereinto from being affected by the heat of the particles heated at a temperature of over 300 °C.
13. An apparatus according to claims 8 and 9 wherein said mixing section is provided below said plates with another plurality of plates (213) for further dispersing the particles dispersed by said upper plates (205), disposed at least where the particles fall in an increased density.

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FIG.1

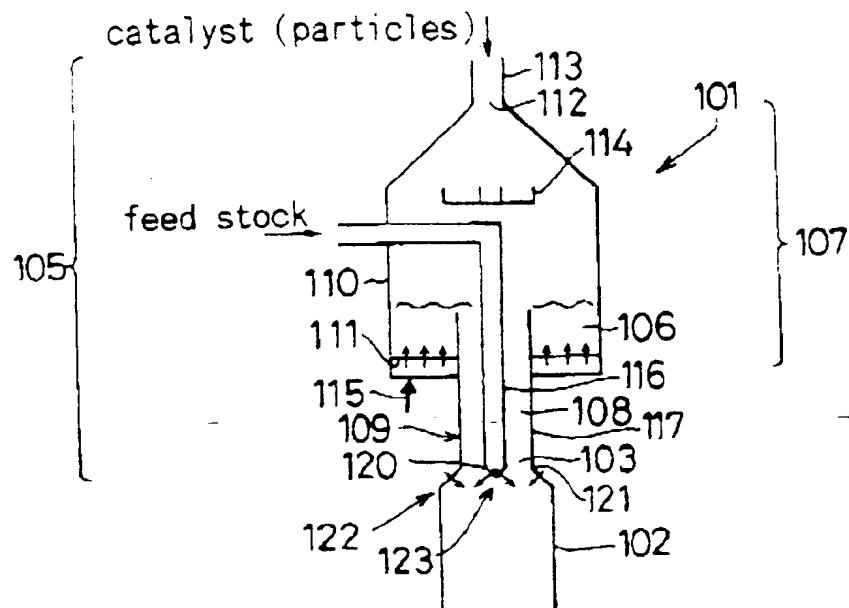


FIG.2

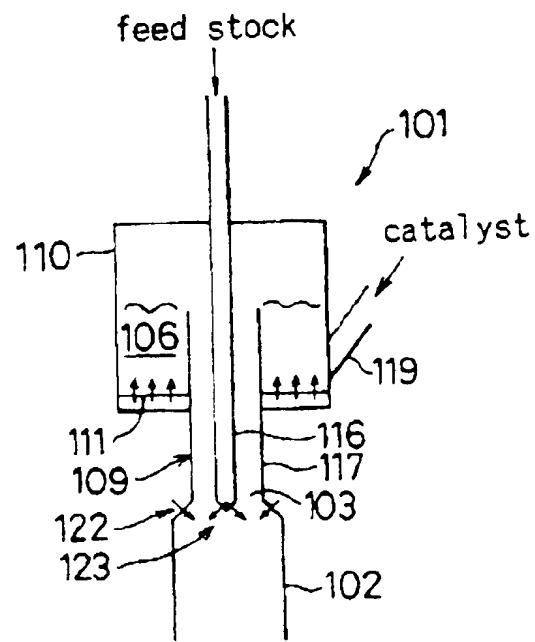


FIG.3

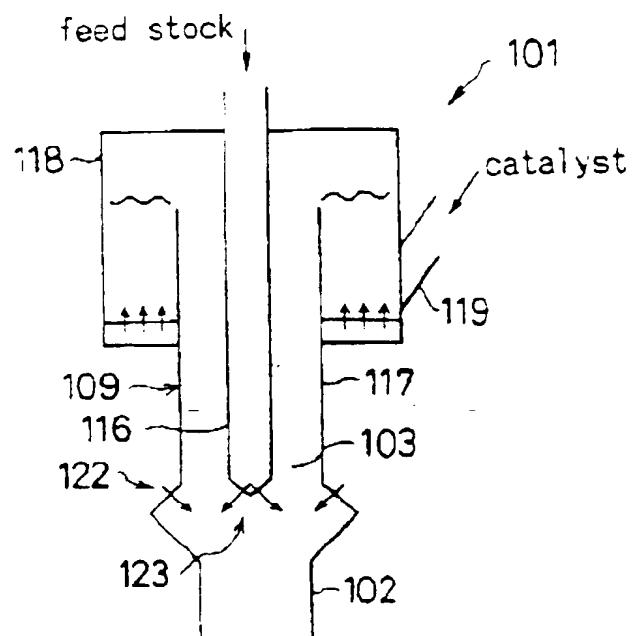


FIG.4

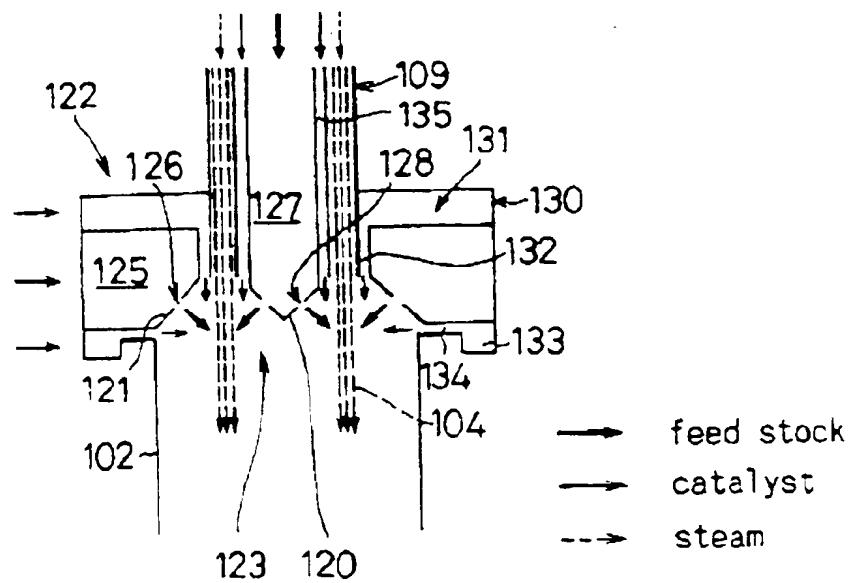


FIG.5

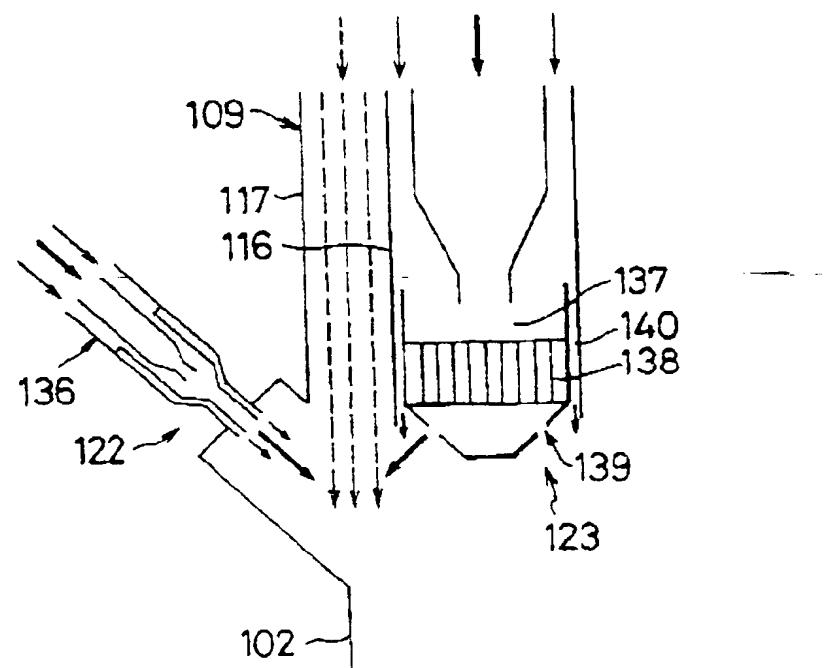


FIG.6

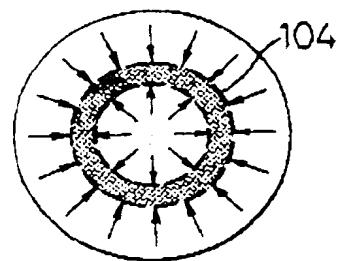


FIG.7

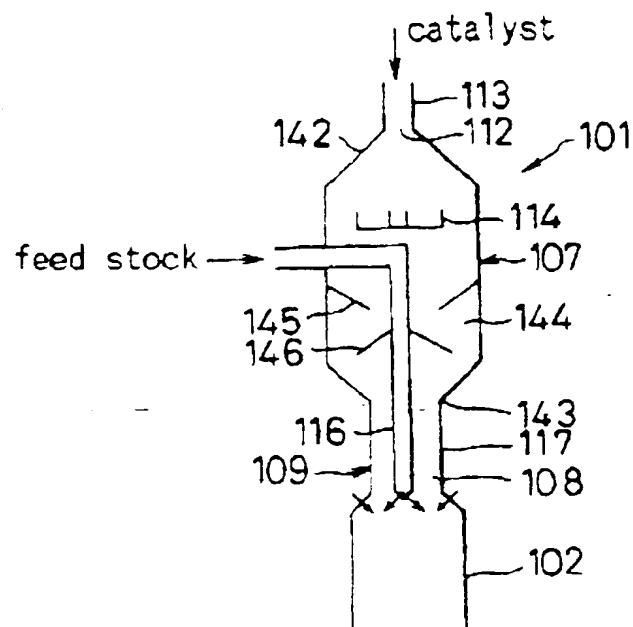


FIG.8

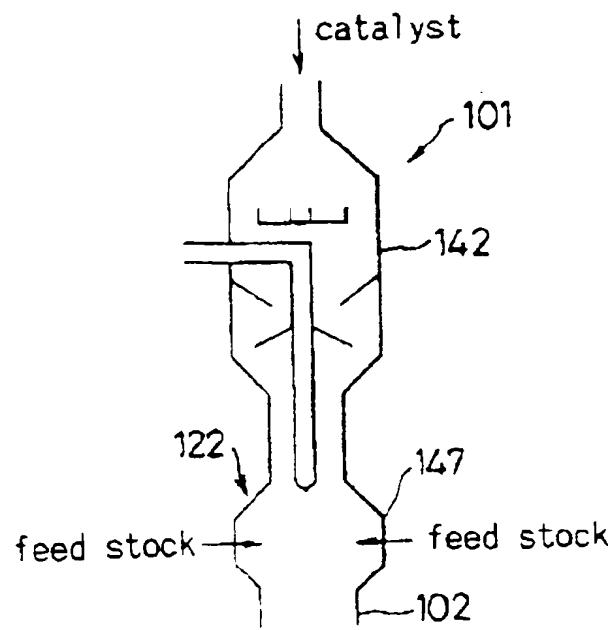


FIG.9

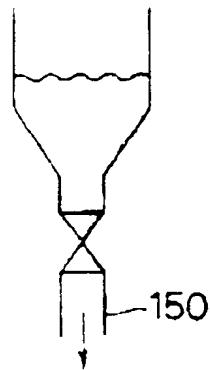


FIG.10

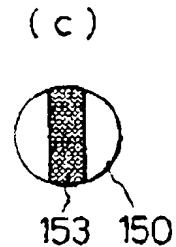
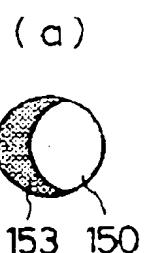


FIG.11

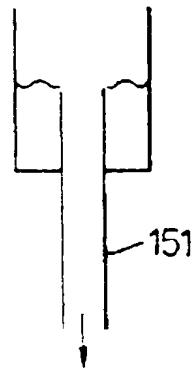


FIG.12

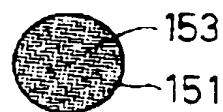


FIG.13

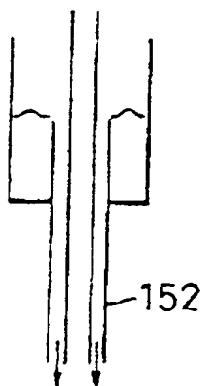


FIG.14

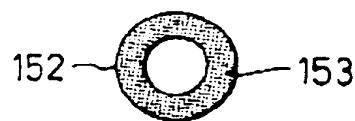


FIG. 15

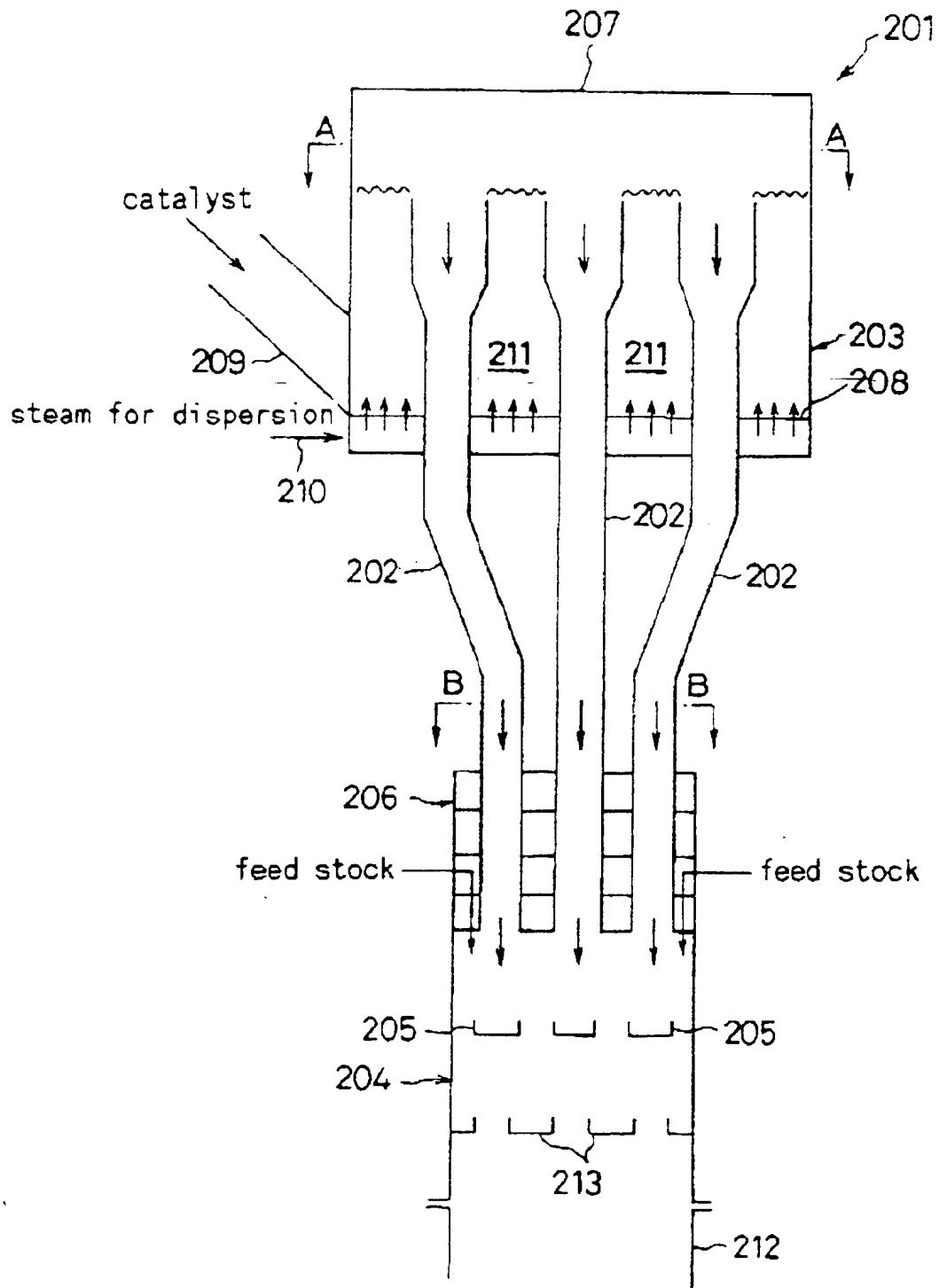


FIG. 16

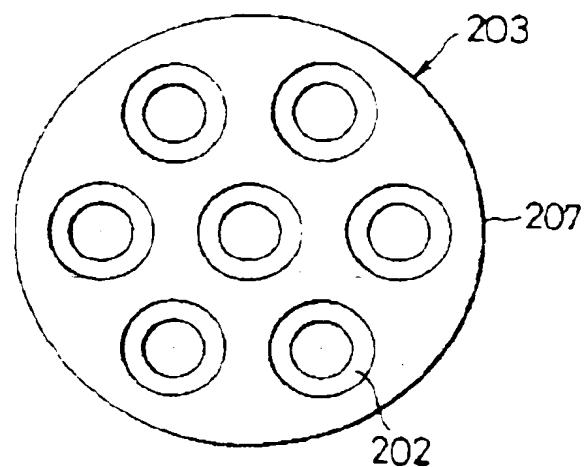


FIG. 17

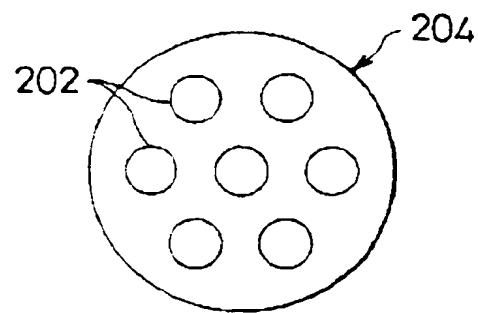


FIG.18

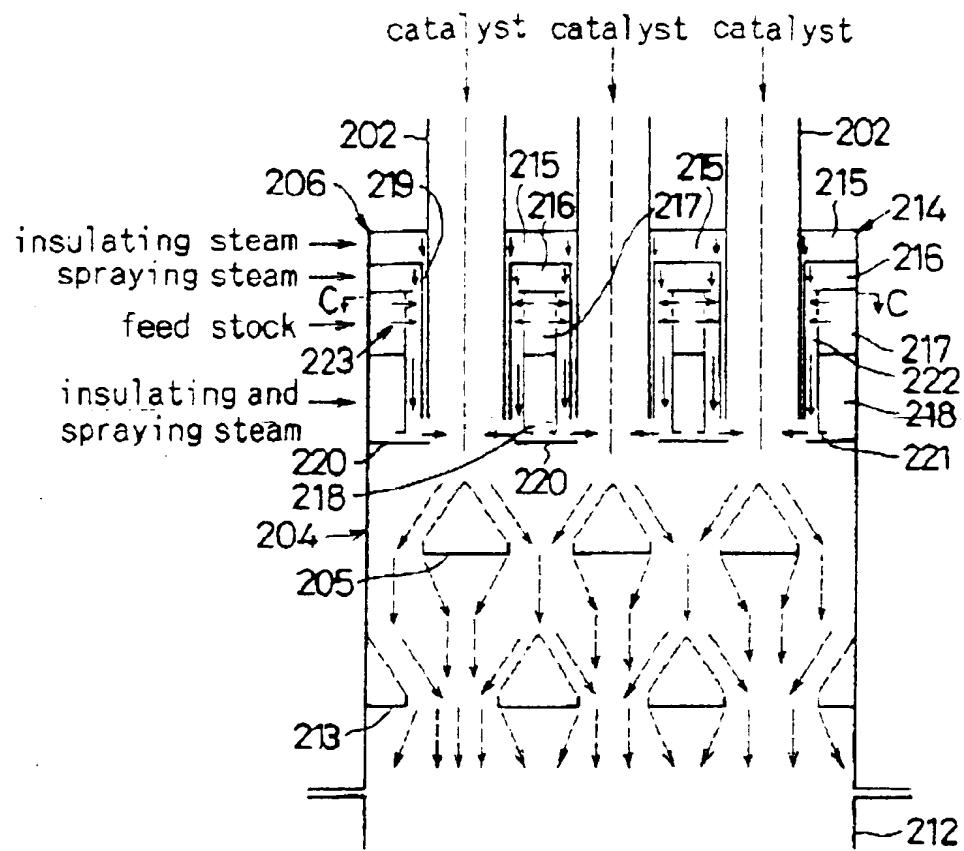
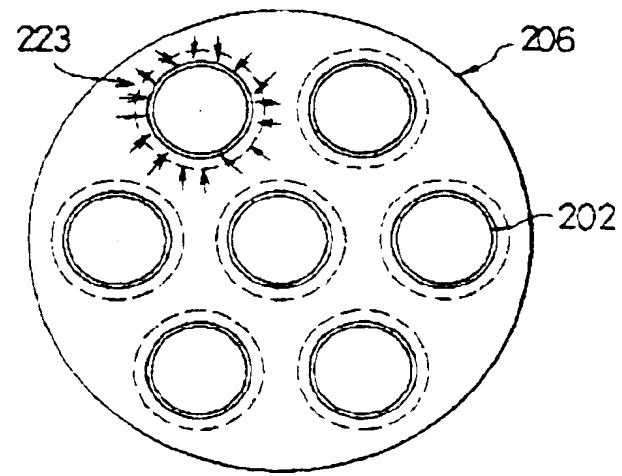
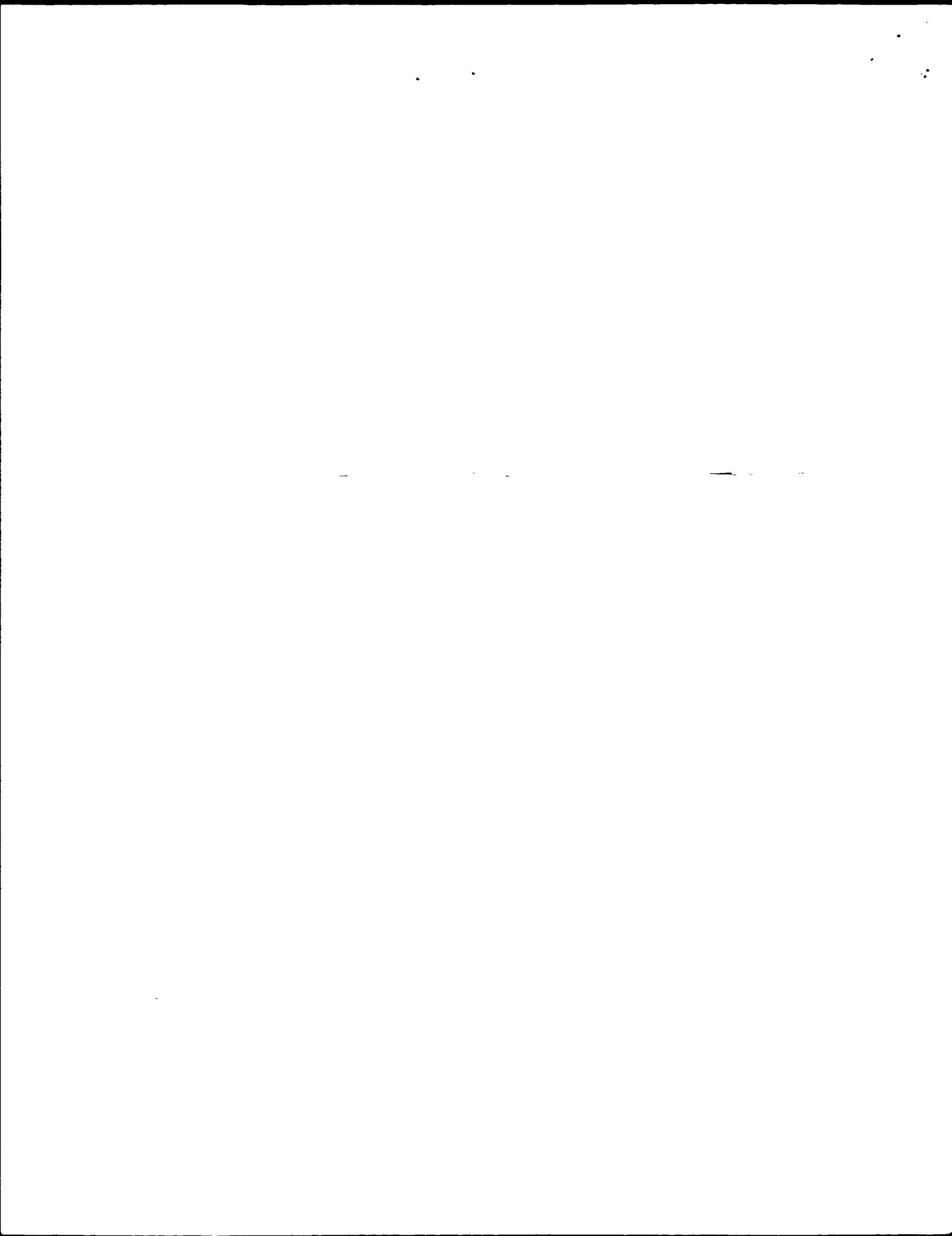


FIG.19





(19)



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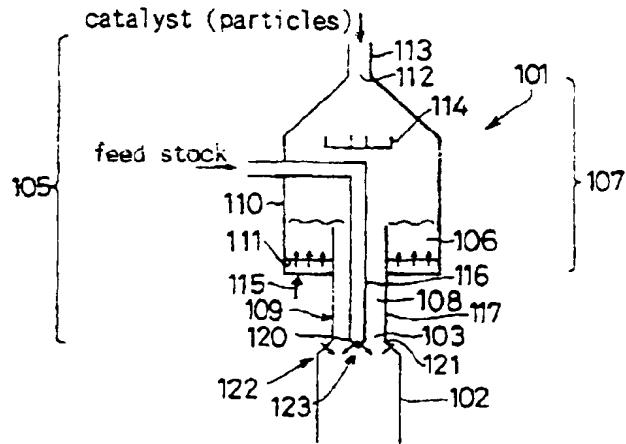
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(54) Apparatus for mixing feed stock and catalyst particles

(57) An apparatus is disclosed for mixing a fluid of a feed stock such as a heavy oil and the particles of a catalyst gasifying the heavy oil in a reactor which comprises the reactor having in the upper portion a circular port through which the particles are fed, a moving bed forming section disposed on and in communication with the reactor for forming the particles into a cylindrical high-velocity moving bed by falling the particles down-

wardly into the reactor while dispersing circularly the particles, an external fluid feed section located so as to spray the feed stock over the entire upper outer periphery of the cylindrical moving bed passing through the reactor and an internal fluid-feed section located so as to spray the fluid over the entire upper inner periphery corresponding to the outer periphery of the cylindrical moving bed.

FIG. 1



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EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation or document with indication where appropriate of relevant passages | Reference to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|----------|---|--------------------|---|
| | | | |
| A | DE 10 36 217 B (SCHOENMAKERS PIETER J) 14 August 1958 * claims 1,4,5,7,9 * * column 5, line 52 - column 6, line 59 * * figures 1-15 * * esp. fig. 11,13 * --- | 1,2,4-6 | C10G11/16 B01J8/08 C10G11/16 |
| A | US 5 296 131 A (RATERMAN MICHAEL F) 22 March 1994 * column 6, line 22 - column 7, line 35 * * column 9, line 45 - line 51 * * figure 2 * --- | 1,2,4 | |
| A | BE 715 089 A (TEXACO DEVELOPMENT CORPORATION) 30 September 1968 * figure 1 * --- | 1,2,8,9 | |
| A | US 3 071 540 A (MCMAHON JOSEPH ET AL) 1 January 1963 * column 4, line 40 - line 73 * * figure 2 * --- | 1,7,12 | |
| A | US 4 323 314 A (KAISER-WIRZ MAX) 6 April 1982 * claims 1,2 * * figures 1,2 * ----- | 1 | TECHNICAL FIELDS SEARCHED (Int.Cl.6) C10G B01J |

The present search report has been drawn up for all claims

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| Place of search | Date of completion of the search | Examiner |
| THE HAGUE | 28 October 1998 | Zuurdeeg, B |
| CATEGORY OF CITED DOCUMENTS | | |
| <input checked="" type="checkbox"/> particularly relevant if taken alone <input checked="" type="checkbox"/> particularly relevant if combined with another document of the same category <input type="checkbox"/> technical background <input type="checkbox"/> non-written disclosure <input type="checkbox"/> intermediate document | | |
| T: theory or principle underlying the invention E: earlier patent document, but published on or after the filing date D: document cited in the application U: document cited for other reasons S: member of the same patent family, corresponding document | | |